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Limnological structure of hydrocarbon lakes on Titan

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Several putative liquid hydrocarbon lakes have been recently detected in the polar region of Saturn's moon Titan by the Cassini radar. The physical properties of the lake and their temporal evolution under present Titan's climatic setting are investigated by means of a 1-dimensional lake thermal stratification model. It is shown that the lakes can undergo various evolutions depending on the initial composition and depth of the lake and hydrocarbon abundance in the near-surface atmosphere. Pure methane lakes have no chance of surviving since they evaporate, freeze up and eventually dry up. On the other hand, lakes filled with a mixture of methane, ethane and nitrogen are more stable and freezing or drying up can be prevented in most cases. These lakes undergo a seasonal cycle of thermal stratification in spring and early summer and convective overturning in other seasons, affecting the vertical exchange of dissolved gases and solids within the lake, between the lake and atmosphere and between the lake and lake sediments. In deep lakes the seasonal temperature variation and convective mixing is confined to the upper layer, while the lake interior is stagnant. The summer thermal stratification near the lake surface can be destabilized by bottom heating as a result of an enhanced geothermal heat flux, which could be expected in the vicinity of cryovolcanoes. The most important factor controlling the fate of lakes is the atmospheric ethane abundance near the surface. Most likely the composition of the lake and atmosphere steadily adjust to each other by a small amount of evaporation, while the lake inflow by precipitation may be irregular and depend on the actual meteorological condition.